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2847

CH-3332

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6/24/54 for SUPERVISOR LABORATORY RECORDS
ORNL

HEALTH DIVISION

* * *

HEALTH-PHYSICS SECTION

AIR MONITORING AT SITE "X"

by

J. S. Cheka
6/31/45

Series A Received: 11/21/45
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by

J. S. Cheka

INTRODUCTION

Atmospheric radiation surveys at "X" were begun with two main ends in view. First, it was to be established that the fission products discharged into the air did not constitute a health hazard on or near the plant site. Second, observed radiation levels, especially the part due to the Separations Plant stack, correlated with meteorological conditions were to be used as an indicator for probable values to be expected at "W".

Several meteorological instruments were installed to determine the prevailing weather conditions of the region. A summary of these observations was kept. Various methods of determining radiation levels were used. The latter observations were correlated with the weather data to determine controlling factors.

INSTRUMENTS

The first group of meteorological instruments was installed late in 1943. It comprised an anemometer, a wind direction indicator with recorder, and a temperature recorder with sensitive elements at several levels. These instruments were installed on the water tower, which is located on the highest ground on the plant site.

The following elevation figures give relative positions of the instruments to other parts of the plant.

1. Elevation of valley floor		774 ft.
2. Elevation of water tower fottings		887 ft.
3. Elevation of 100 and 200 stack bases		860 ft.
4. Elevation of 100 and 200 stacks		1060 ft.
5. Elevation of wind instruments		1027 ft.
6. Height of thermometers above tower base, as originally installed -	a	33 ft.
	b	83 ft.
	c	133 ft.
	d	183 ft.

From these figures it is evident that the wind instruments are at approximately the level of the tops of the stacks. Also it can be

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seem that the vertical temperature gradient can be ascertained in a 150 ft. range between the top and bottom thermometers. In June of 1944 another thermometer was installed 3 ft. above ground level. This increased the observational range for temperature gradient to 180 ft. and made it more representative, since it included the surface temperature.

A humidigraph was added at about this time, but, since it was only approximate, as checked against a psychrometer, another thermometer with a wet wick cover was installed on the lowest point on the water tower, giving recorded wet-bulb readings.

WIND THEORY

The region in which Clinton Laboratories is located lies south of the Prevailing Westerly belt, but above the belts of Northeast Trades. Except during a few months of the winter, when the southerly drift of the Prevailing Westerly belt brings this region under partial influence of its cyclonic storm paths, the pressure gradients are very slight. It has been observed that during the four months of June - September 1944 the total pressure variation was 0.5". Under these conditions there can be no strong winds, and air mass movements are controlled by local factors. The terrain is the most significant of these local factors. The region consists of a series of mountain ranges and valleys, running NE and SW. Consequently, almost half the time during the period covered by these observations, the wind was either NE or SW. The other large component wind frequency is W, comprising 23.7% of the total. Seasonal distribution of wind direction frequencies is shown in the graph, Figure 1, which is appended.

WIND FINDINGS

This graph shows that NE winds are fairly general but show some increase in the winter months. W winds are quite a minor factor in the summer months but are frequent in winter. SW winds reach their highest frequency in the summer months.

While wind velocities of over 20 mph have been noted, the average throughout the period is less than 5 mph, and zero velocities often occur, especially at night. Wind analysis has also shown that the average is higher in winter than in summer. Diurnal ranges show a tendency for maximum velocities to occur between noon and six PM, and minimum between midnight and 6 AM. This effect is much more pronounced in the summer months. Figure 2, showing hourly mean wind velocities for the months of February - June 1944 illustrates this phenomenon.

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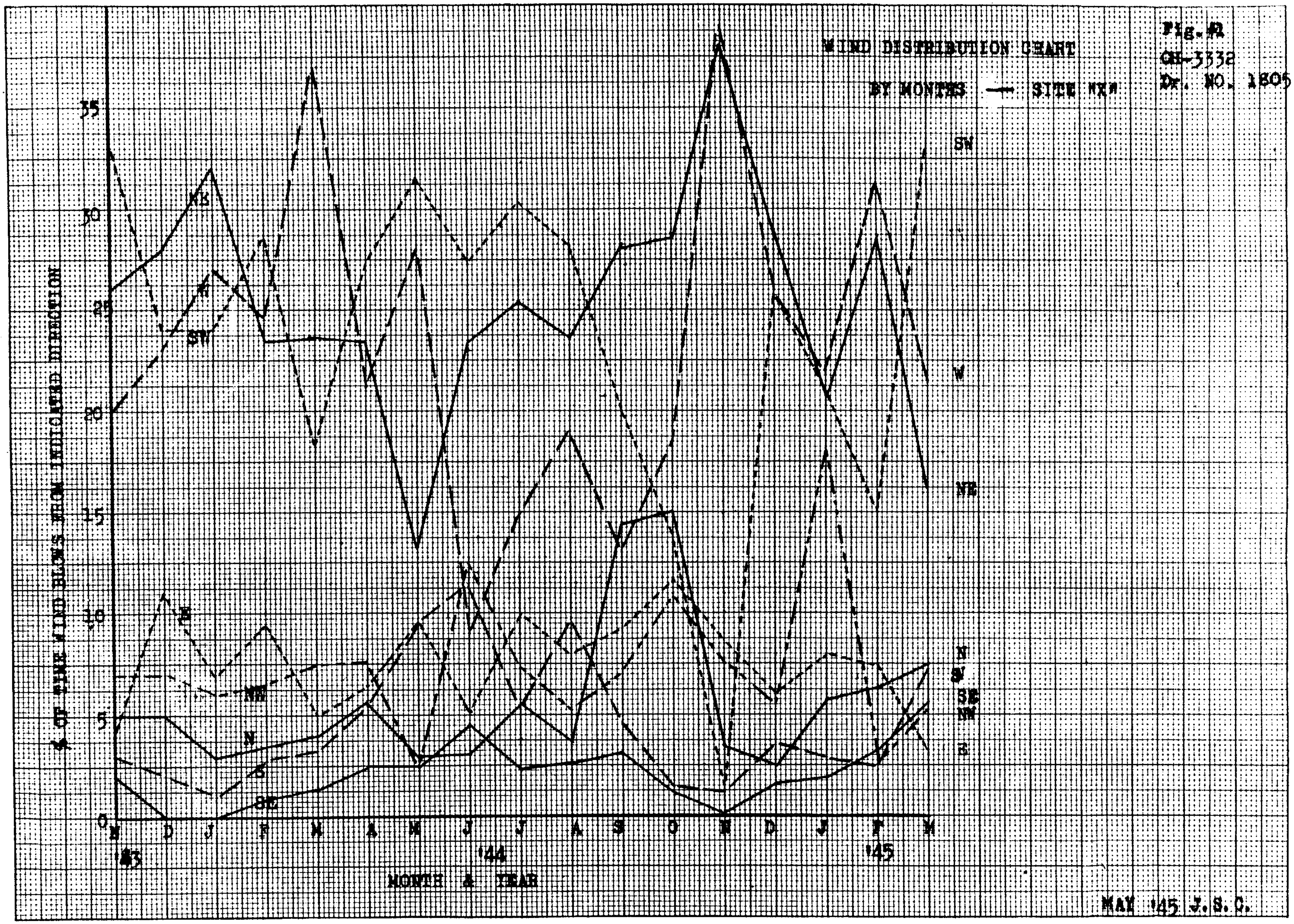
WIND DISTRIBUTION CHART
BY MONTHS — SITE "X"
Fig. #2
CH-3332
Dr. NO. 1805
% OF TIME WIND BLOWS FROM INDICATED DIRECTION
0
5
10
15
20
25
30
35
N
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
'43
'44
'45
MONTH & YEAR
SW
W
NE
N
S
SE
NW
E
MAY '45 J.S.C.

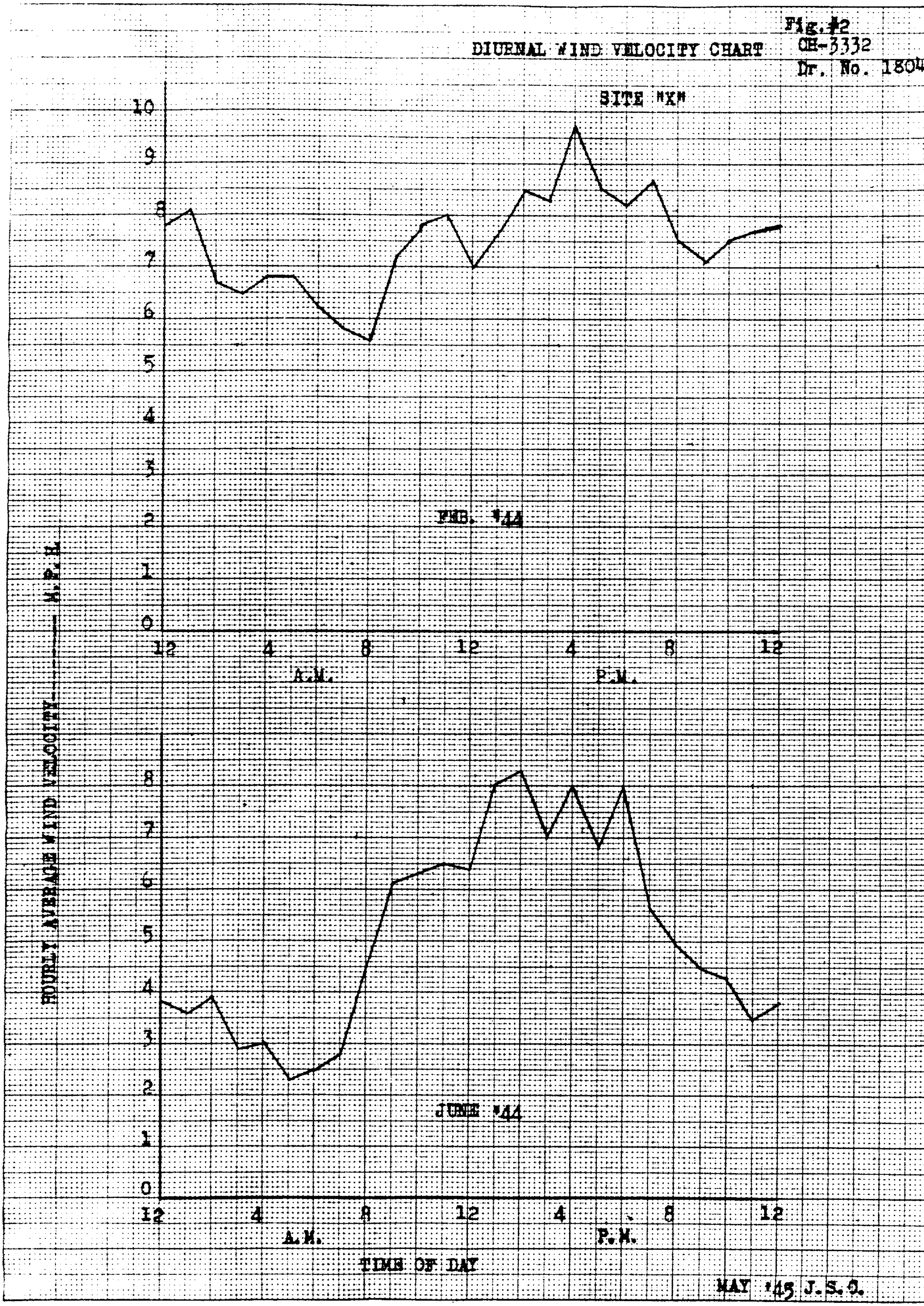
Fig. #2
CH-3332
Dr. No. 1804
DIURNAL WIND VELOCITY CHART
SITE "X"
FEB. '44
JUNE '44
HOURLY AVERAGE WIND VELOCITY ——— M.P.H.
0
1
2
3
4
5
6
7
8
9
10
12
4
8
12
4
8
12
A.M.
P.M.
TIME OF DAY
MAY '45 J.S.O.

[redacted]

The irregularity of the topography of the region, together with the extremely small pressure gradients result in frequent light, variable winds, and considerable turbulence in the surface atmosphere. Winds in four different directions at different levels have been observed. These cross-currents are especially frequent when the prevailing wind cuts across the mountain ranges. However, a NE or SW wind, blowing up or down the valley is very likely to be steady.

INVERSIONS

The low nocturnal average wind velocities are very conducive to temperature inversions on clear nights. These are reversals of the temperature gradient. Normally, the temperature of the atmosphere decreases with altitude. This condition is inherently unstable because of the decrease of density of air due to thermal expansion. This causes vertical currents and turbulence, and is the source of cumulus clouds. Under these conditions air masses will rise until their densities reach equilibrium with that of surrounding air through adiabatic cooling.

An inversion may be of two origins. A wind shift may bring in an air mass of different temperature. If the new mass is warmer than the air already present, it over-rides the cooler air because of its lesser density, thus creating an inversion. If colder, the wind-front wedges under the lighter air, and the effect is similar.

The other type is that caused by nocturnal terrestial radiation. This phenomenon occurs when there is little or no wind and cloud cover. An inversion of this type begins as soon as the sun sets, or even before sunset if a location is in shadow. It is caused by the cooling of air in contact with surface objects which become cooled by radiation. If there is considerable cloud coverage, thermal radiation is reflected to the Earth's surface, and the total cooling may be very little. If there is an appreciable wind, the turbulence caused by surface irregularities is usually sufficient to cause a mixing of the cooled layer with the main body of air and destroy stratification.

An inversion is a stable condition, since the heaviest air is at the lowest level. Under these conditions there is a tendency toward stratification, which is more pronounced as the negative temperature gradient increases. These inversions break up soon after sunrise, although they may last late into the morning if clouds prevent insolation. Sunshine brings about a quick warming of the surface air layer, and a consequent unstable condition, causing convectional turbulence.

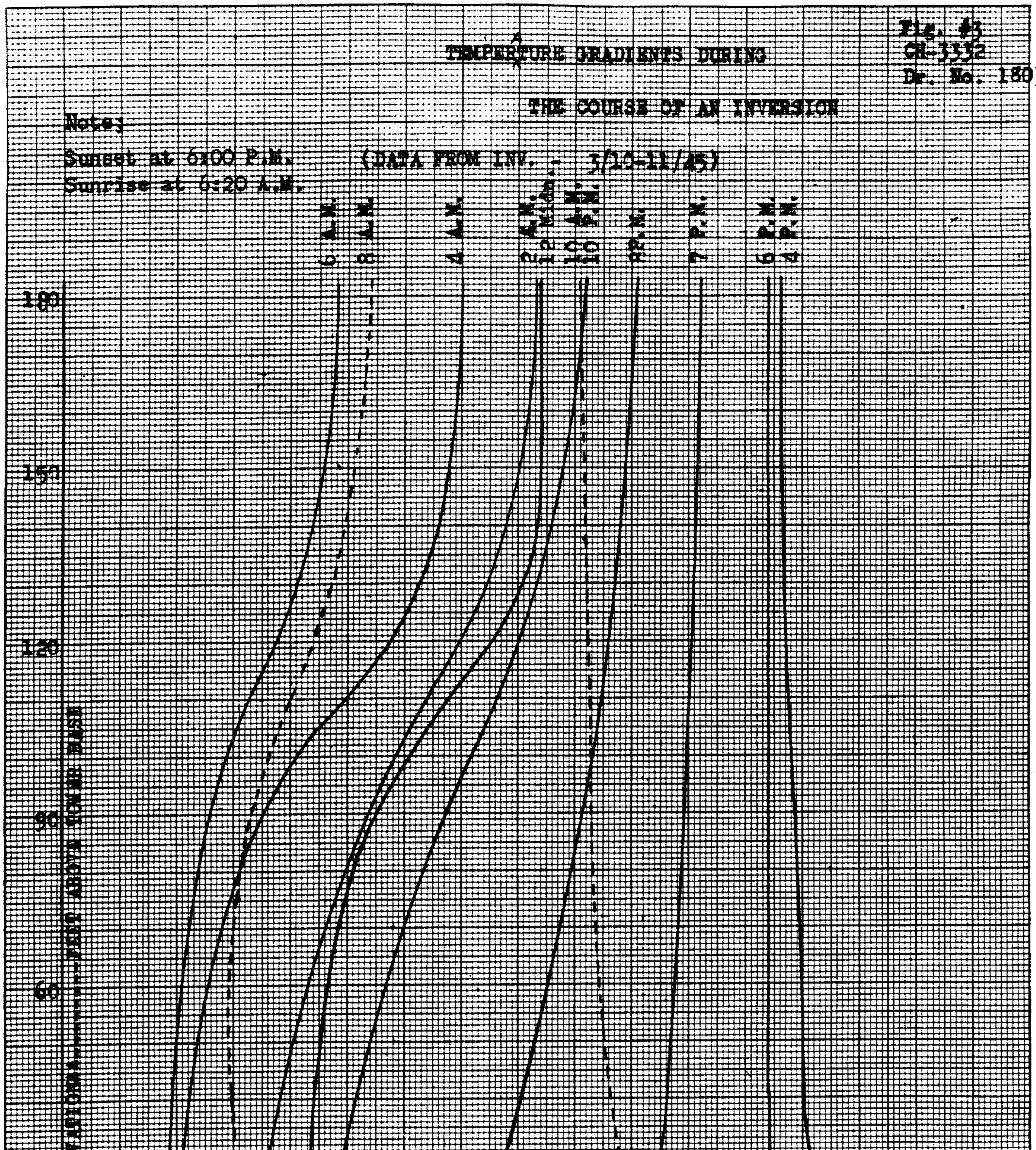

Fig. #3
CH-3332
Dr. No. 1803
TEMPERATURE GRADIENTS DURING
THE COURSE OF AN INVERSION
Note;
Sunset at 6:00 P.M.
Sunrise at 6:20 A.M.
(DATA FROM INV. - 3/10-11/45)
6 A.M.
8 A.M.
4 A.M.
2 A.M.
12 Mdn.
10 P.M.
10 A.M.
8 P.M.
7 P.M.
6 P.M.
4 P.M.
ELEVATION — FEET ABOVE TOWER BASE
180
150
120
90
60
30
0
30
35
40
45
50
55
60
65
TEMP. DEGREES FAHR.
MAY '45
J. S. C.

[redacted]

Figure 3 shows the changes in the temperature gradient during the course of an inversion of radiational type. The first curve (4 PM) shows a normal gradient. The first signs of inversion appear at 7 PM near the surface. The region of greatest negative gradient (and therefore the most stable stratum) rises as the night progresses. At 8 AM we have the beginning of the breakup and by 10 AM the normal gradient is re-established.

Since the foot of the tower where the instruments are located is over 100 ft. above the valley floor, it is evident that the inversion started earlier in the valley and was probably of much greater range. It has been noted at various times that the apparent layer of greatest stability often passes above the range of our instruments. The position of this stratum is of importance in considering its effect on stack gases.

RAINFALL

Normal rainfall for this region (72 year records at Knoxville) is 49.77" per year. It is fairly uniformly distributed except for a slight preponderance in the late winter and early spring. Severe storms with heavy precipitation are rare, but there were a few with 2" or more of rain, and one on September 29, 1944 precipitating 8.81" of rain. The latter was a Gulf storm, the center passing somewhat south of this area.

Relative humidity is usually high, averaging well over 60% most of the time.

Figures for cloud coverage taken locally cover only times of observation, 8 AM, Noon, and 4 PM. However, Weather Bureau reports show that the average cloud coverage for this region is well over 50%.

CONTAMINANTS

As H. M. Parker pointed out in CH-2562, the chief sources of atmospheric contamination are radioactive Xenon and Iodine, which are fission products and were discharged in the "off-gas" from the Separations Plant through the 205 stack, and activated Argon from the Pile Building through the 105 stack. Mr. Parker indicated the relative quantities of the above mentioned gases, as of June 1944 when the pile power level was lower than at present, as follows:

Stack	Radioactive Isotope	Average c/day	Relative Ionization γ	Relative Ionization $\beta + \gamma$
105	Argon	200	740	1300
205	Xenon	11	1.2	5.3
205	Iodine	1	1	1.6

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[redacted]

The Argon activity depends upon the power level of the pile, and at present is about 500 c/day. The 205 operations were discontinued on January 3, 1945, but this decrease was partially off-set by Xenon and Iodine discharged from the 706C and 706D Lanthanum Separations Buildings (706C started hot operations in September 1944, and 706D in May 1945).

Xenon and Iodine from separations were discharged together with considerable NO_2 from the chemical treatment. Since this mixture was somewhat heavier than air, under certain conditions it tended to fall to the ground. By following the clouds of NO_2 fumes, fairly high activity could sometimes be found for short periods. Also, since it was detectable by its odor, as well as its color, it could be traced easily. The earliest radiation measurements were taken in spots where these fumes reached the ground. However, evidence here and at Hanford seems to indicate that the radioactive gases do not always follow the NO_2 fumes.

Argon, activated as the cooling air passes through the pile, occurs in much larger amounts, but has not been noted in concentration near the ground. It has a short half-period, 110 minutes, compared to 8 days for Iodine and 5.4 days for Xenon. On the other hand its radiations are more energetic, 1.37 Mev γ and 1.5 Mev β compared to .4 and .08 Mev γ and .68 Mev β for Iodine and .08 Mev γ and .3 Mev β for Xenon.

External radiation tolerances have been calculated to be 7×10^{-12} curie/cc for Iodine, 2.3×10^{-11} curie/cc for Xenon, and 1.8×10^{-12} curie/cc for Argon. Since Iodine is deposited in the thyroid, its tolerance cannot be determined by external radiation alone. Consequently, Iodine tolerance has been set at 10^{-13} curie/cc.

Since September 1944, on several occasions, slugs with burst jackets were found in the pile. Such occurrences introduce other contaminants in the form of fission products and Uranium in solid particles into the cooling air.

RADIATION MEASURING INSTRUMENTS AND MEASUREMENTS.

The earliest radiation measurements were taken at various times from November 1943 to March 1944 with a Lauritsen electroscope. The measurements were taken when the 205 stack gases reached the ground. Readings up to 0.1 mr/hr were obtained for very short periods. It was noted that for short distances, radiation intensity increased with distance.

In the courses of normal turbulence caused by wind, the stack-gases reached the ground in greatest concentration at about seven times stack height. In such cases the air dilution is quite large. The

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Conditions under which greatest concentration may be expected are those found at the end of an inversion in the morning. When the "ceiling" of the inversion is above the top of the stack, the fumes are held below it, and since there is little or no wind when such inversions occur, there is comparatively little dilution and the heavy fumes often drift to the ground. Also, at the breakup of an inversion, the down-draft currents, which develop to equalize the rising vertical convectional currents, often bring the fumes down to the ground level.

Systematic monitoring of the area for atmospheric radiation was begun in May 1944 by means of X-22 chambers. These were developed by H. M. Parker and C. C. Gamertsfelder.

The X-22 chambers are cylindrical bakelite condenser chambers 8" in length and 7" in diameter. The 1/8" walls and central bakelite electrode are coated with aquadag. The volume is 4900 cc and the electrostatic capacity $\sim$10 cm. The walls are of sufficient thickness to exclude most of the beta rays, so that the discharge noted was almost wholly due to gamma radiation.

Half of the chambers were converted to beta sensitive instruments by cutting 48 large holes in the walls. This process removed about 42% of the wall material. These were then covered with aquadag-coated cellophane, but not being able to withstand the weather, this coating had to be discarded. It was replaced by .001" aluminum foil, which was more durable. However, even this was subject to weathering, and this type of chamber could be used only for short periods.

A battery-powered portable Victoreen minometer was used to charge and read the chambers. Full charge was $\sim$140 volts. The standard minometer scale is graduated to 100 divisions, and this scale was extended to about 170 divisions. However, when 100 on the minometer scale is obtained the chamber is discharged to the low value of 75 volts making the extrapolated range unreliable.

X-22 discharge rates were calibrated in terms of minometer scale readings by means of a radium-gamma source. The solid walled, or "gamma" chamber gave .004 mr/div while the converted, or "beta" chamber gave .0035 mr/div. In other words, the difference between readings taken simultaneously on a gamma and beta chamber may not altogether indicate beta radiation.

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Chamber backgrounds, i.e. discharge rates in an uncontaminated location, were determined before each chamber was used in the field. Causes of such discharge are insulation leakage, cosmic rays, and the normal radon and thoron content of the air. The cosmic rays, radon and thoron are always present and cannot be controlled. The insulation leakage, however, depends on the condition of the polystyrene insulation and may cover a large range. It was found that cleaning the insulators with fine sand-paper, then polishing with lint-free tissue paper, sometimes brought resistance leakage down to $<$.1 div/hr. This was determined by placing the X-22 to be tested in an evacuated pressure-chamber. The acceptable background reading was arbitrarily set at $<$ 5 div/hr corresponding to $<$ .020 mr/hr before a gamma chamber was considered fit for field service. Most of the chambers had a background of 4 or as low as 3 div/hr corresponding to .016 or .012 mr/hr respectively. Insulators were re-cleaned and polished and the chambers re-tested until this range was obtained.

Barring some external cause, such as contamination, water in the chamber, or dirt in the nozzle of the chamber, these backgrounds sometimes remained fairly constant for several months at a time. In the field, however, variations in background were often noted. Consequently, in calculating field readings, the lowest readings of a monthly period which repeated were taken as "background" of each chamber for that period. It was assumed that a single low reading was probably due to charging error. This question will be discussed further in connection with the results of field observations.

During March - May 1944, field tests were made with X-22 chambers. These tests were mainly of a few hours duration each, and involved placing the chambers in the path of "off-gas" when these fumes reached the ground during dissolvings in 205. Values of .016 to .040 mr/hr above background were obtained during these runs. Simultaneously, readings as high as 1 mr/hr were obtained for a 2 minute interval in the off-gas stream with a Lauritsen electroscope.

By June 1944 nine stations were set out on and around the plant site. At each station were two stands designed to hold two chambers each, exposed five feet above ground level. The map, Figure 4, shows the location of these stations. The circles appearing on the map are centered on the 205 stack and have radii of 1/2, 1, 1-1/2, and 2 miles respectively. The locations of the several stations with respect to the 205 stack are as follows:

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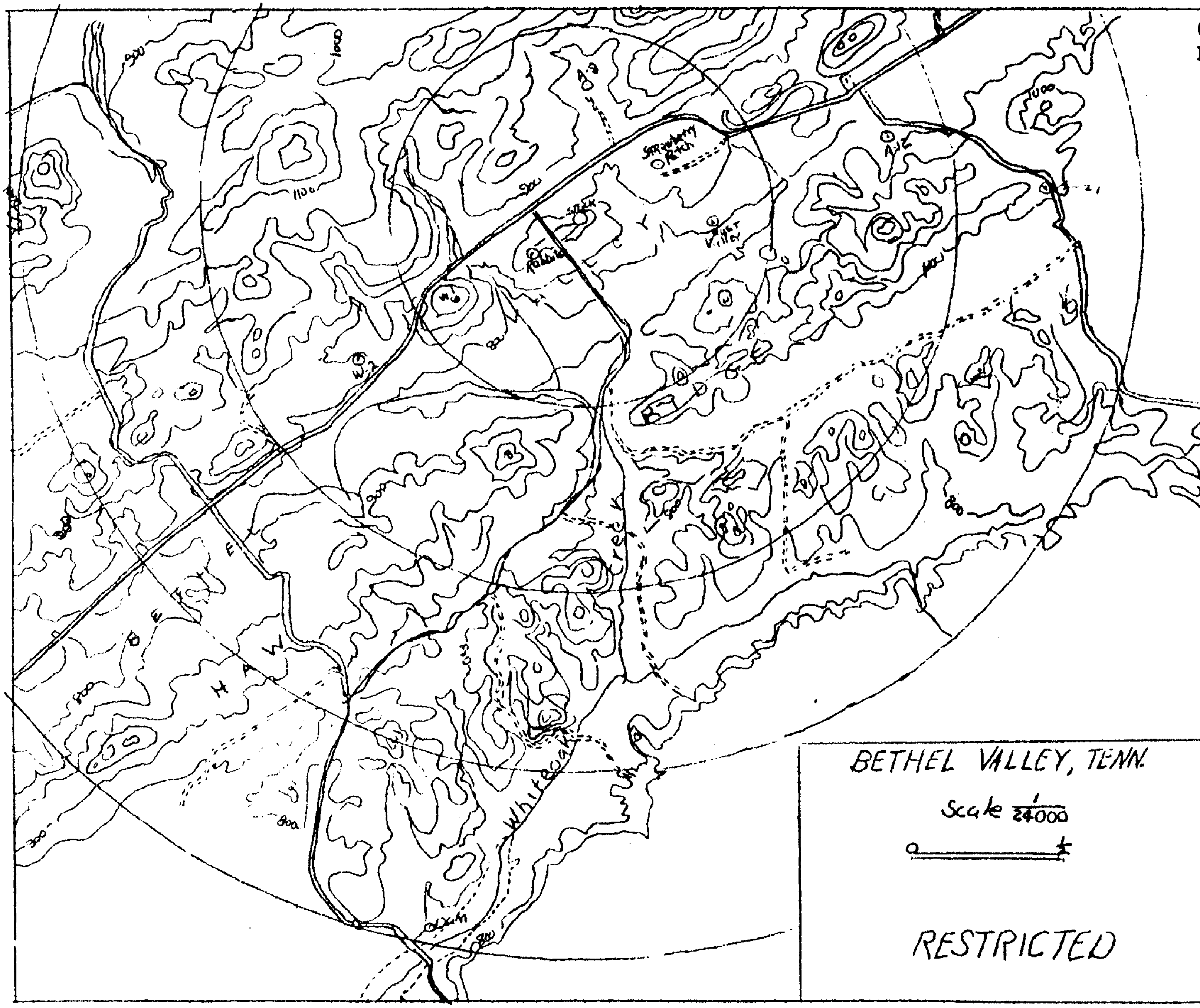
CH-3332
Dr. No. 1806



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Station	Direction	Distance
A-21	E	6600 ft.
A-12	NE by E	4700 ft.
East Valley	E	2100 ft.
Strawberry Patch	NE	1650 ft.
A-8	N	1900 ft.
Rabbits	SW	800 ft.
W-1	SW	2000 ft.
W-2	SW	3700 ft.
Dam	S	10,300 ft.

In September another station, High Point, was set up NE of the plant at a distance of 14,800 ft.

It was originally intended that each station should have two gamma chambers, and two of the beta type. One of each type was intended as a control on the other, and the two types were to give comparative values of γ against ($\gamma + \beta$) radiations. In practice, the gamma chambers were found to be sufficiently sturdy to function without trouble for months at a time in many cases, so that there was usually a full complement, i.e. two, of this type at each station. The beta chambers, however, even with the aluminum covering proved not to be sufficiently weather-worthy to function for more than a few weeks at a time, at best. Consequently there is a fairly complete set of data on gamma observations, but that on beta chambers is fragmentary.

It may be noted that most of the stations lie in directions NE, E and SW of the plant stacks. Since almost 75% of the total observed wind blows in these three directions, this is a logical distribution to check correlation with winds. The exception is the Dam station which was so placed with the purpose of gathering radiation data from White Oak Lake.

It was immediately apparent that there was a high degree of correlation between wind direction and high readings to the lee of the stacks. The effect of a shift in wind toward a station was more marked than that of a shift away from a station. In other words, it seemed to require more time for contamination to be cleared away, though a renewal of active contaminants would show up immediately. Zero, or rather, background readings to windward were found in most cases if the wind remained steady for a day or more.

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While during the period comprising June - August, 1944, maximum readings for an 8 hour observation reached .0216 mr/hr above background at the Rabbit cages, the highest monthly average value (also at the Rabbit cages) amounted to .0082 mr/hr. Background, as previously mentioned was about .012 to .016 mr/hr.

Theoretical rule of thumb calculations of stack effluent dilution rates give the greatest concentration of fumes at ground level at about 7 to 10 times stack height, at which point the fumes first reach the ground. Then dilution increases with the square of the number of stack lengths. Observed figures at "X" do not bear this out.

Average monthly values for August for the various stations, together with other pertinent data appear in the table below:

Station	Distance from stack	Elevation	monthly Av. mr/hr	Direction	% of Wind Toward Station
RC	800 ft.	880 ft.	.0082	SW	24
W-1	2000 ft.	860 ft.	.0044	SW	24
W-2	3700 ft.	860 ft.	.0044	SW	24
A-8	1900 ft.	840 ft.	.0026	N	9.5
SP	1650 ft.	900 ft.	.0044	NE	28
EV	2100 ft.	800 ft.	.0031	E	18
A-12	4700 ft.	820 ft.	.0012	ENE	22
A-21	6600 ft.	980 ft.	.0037	E	18

It appears from the foregoing table that the above mentioned 7 to 1 stack rule breaks down when applied to "X". RC, which is only 4 stack-lengths away has almost double the contamination of SP which is 8. Also, dilution factors do not follow the exponential rule. The discrepancies are probably due to two causes. The greater density of the off-gas, compared to air, often caused a drop of clouds of the fumes much nearer than expected, unless driven by a brisk wind. This was especially true at the end of an inversion, when occasionally the fumes would linger in various spots for a considerable time. Besides this, the topography of the area prevented a normal diffusion rate. The latter having been calculated for a flat surface with no obstruction.

For example, if W-1, SP and EV are compared, the distances are found to be within the same range, but readings at EV are about 70% of those at the other two stations. The factor that seems to explain this is that of elevation. W-1 and SP are ~80 ft. higher. Also, when EV is compared with A-21, both lying in the same direction, A-21 though three times as far has higher values recorded. Topographical study shows that A-21, though 980 ft. in elevation lies between two higher hills, and this gap has a funnelling effect, reconcentrating the gases of the stack.

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It was also estimated, by comparing of average readings on days with and without off-gas from the dissolver, that the Argon from the 105 stack contributed about 80% of the field radiations. Since this is less than expected from the curie content of the respective stack discharges, it appears that the 105 effluent behaves differently from that of the 205 stack.

To begin with, at 125.000 cfm through a 5'9" stack mouth, the speed of the stream is about 80 ft/sec. In still air, 100 ft. above the stack mouth, the air stream will still have an upward velocity of ~13 ft/sec. Then, since the temperature is about 200°F, it is 27% lighter at the stack mouth than surrounding air at 68°F, or 37% lighter if the air is 32°F. Assuming heat dissipation to be due to mixing alone, other factors being small, the air stream 100 ft. above the stack mouth will still be 4% lighter than surrounding air at 68°F or 10% lighter if the air is at 32°F. Since during an inversion the general air temperature is usually low, the latter condition is approximated. Also, during an inversion wind velocities are low and there is less chance of the convectional current set up in this reaction to be disturbed. (CE-1398).

Walkie-Talkie checks made during August at X-22 stations gave maximum values of about twice background for two minute intervals.

On September 11, a new schedule was established for taking field readings. Observers worked on shifts, and readings were taken at 8 hour intervals. It was expected that this would give a more complete and uniform set of data, and that analysis would probably bring out the effects of temperature inversions, and other influences. However, September also saw the first of several slug ruptures in the 105 Pile, and these occurrences introduced new factors into the problem.

A slug rupture probably occurs because of a small hole in the container. This allows oxidation of the metal and fission products until the pressure of the oxides is too great for the strength of the container, and it bursts open. There is then a release of fission products, such as active Xenon and Iodine, which would ordinarily not be free until a dissolving, after considerable decay. It is also probable that solid oxides of heavier fission products are also carried out by the cooling air, these apparently settling to the ground near the plant. The field effects are, an immediate rise in readings to more than double the usual values and a persistent activity most noticeable nearest the plant stacks. The latter effect caused a rise in chamber background which dropped somewhat after any considerable rainfall. By February 1945 chamber backgrounds were at the level of the previous summer.

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Figure 5 shows total monthly readings at five representative stations together with activity indices for 105 and 205, i.e. the pile and separations plants. These are ratios of pile power and number of dissolvings respectively, referred to those of June. The field values are corrected for backgrounds determined each month as previously outlined (i.e. this background is the lowest during the month if it was repeated that month).

It is evident in general that field activity is more dependent on the pile activity than on the dissolver. However, it can also be seen that values from September to December are much higher than would be expected, and that the greatest rise is at the nearest stations.

Assuming that all of the change in background was due to solid particles released during slug ruptures and settling out of the air, field totals for these same stations were recalculated on the basis of the original chamber backgrounds. These values appear in Figure 6. From this it appears that the residual contamination all occurred within a mile of the plant (no effect at A-21) and that the degree of contamination is almost inversely proportional to the distance from the stack within this range.

Further check on this residual activity showed that there was a drop in background readings after any rainstorm of 1/2" or more. Also, an experiment whereby the chambers from an uncontaminated area (A-8), where the background had remained constant) were exchanged with those at the most contaminated station (RC), showed that the background of the area rather than that of the chambers had changed.

Figure 7 shows the correlation between wind direction and readings down wind. The values here shown are percentages of total monthly radiation at all stations through monthly periods recorded at the specified stations, plotted along with percentage of total wind flowing toward the respective stations for the corresponding periods. The correlation is excellent until after September when the residual activities due to slug ruptures flattened the field curves. After January much of this activity had cleared up, and the correlation improved somewhat.

Short-time correlation is often more striking, a shift in wind toward a station bringing about high readings, and a shift away causing a drop to or near background readings.

Had it not been for the several slug ruptures, a much clearer picture of the distribution of the purely gaseous contaminants could have been obtained with the stations used. Also, if the observed values had been of greater magnitude, it might have been advisable to expand the program to get more complete coverage.

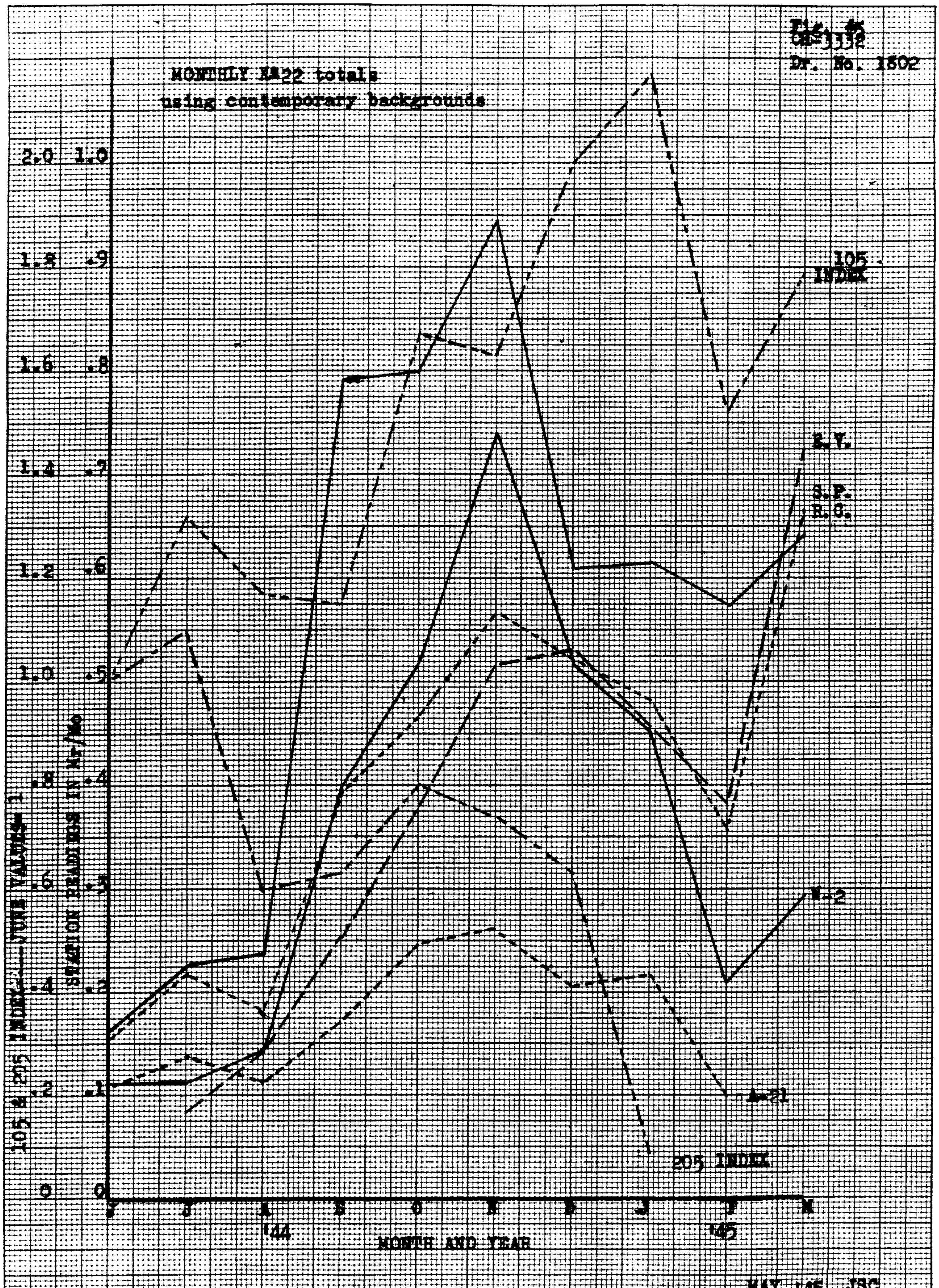


Fig. #5
CH-3332
Dr. No. 1802
MONTHLY NA22 totals
using contemporary backgrounds
2.0 1.0
1.8 .9
1.6 .8
1.4 .7
1.2 .6
1.0 .5
.8 .4
.6 .3
.4 .2
.2 .1
0 0
105 & 205 INDEX— JUNE VALUES=1
STATION READINGS IN Mr/Mo
105 INDEX
E.V.
S.P.
R.G.
W-2
A-21
205 INDEX
J J A S O N D J F M
'44 '45
MONTH AND YEAR
MAY '45 JSC

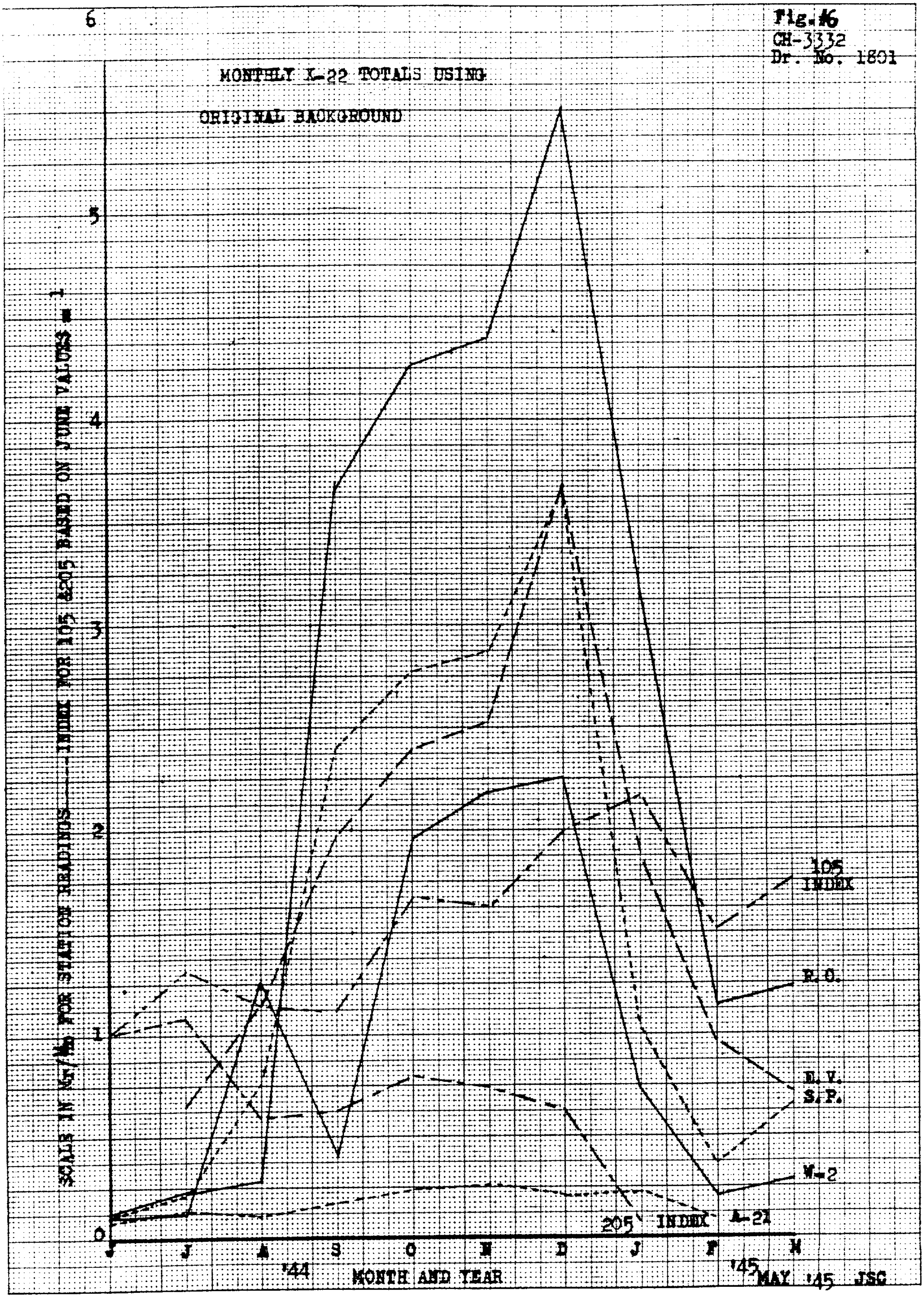


Fig. #6
CH-3332
Dr. No. 1801
MONTHLY X-22 TOTALS USING
ORIGINAL BACKGROUND
SCALE IN Mr/Hr FOR STATION READINGS——INDEX FOR 105 &205 BASED ON JUNE VALUES = 1
6
5
4
3
2
1
0
105
INDEX
R.O.
E.V.
S.P.
W-2
205
INDEX
A-21
J
J
A
S
O
N
D
J
F
M
'44
MONTH AND YEAR
'45
MAY '45 JSC

CH-3332

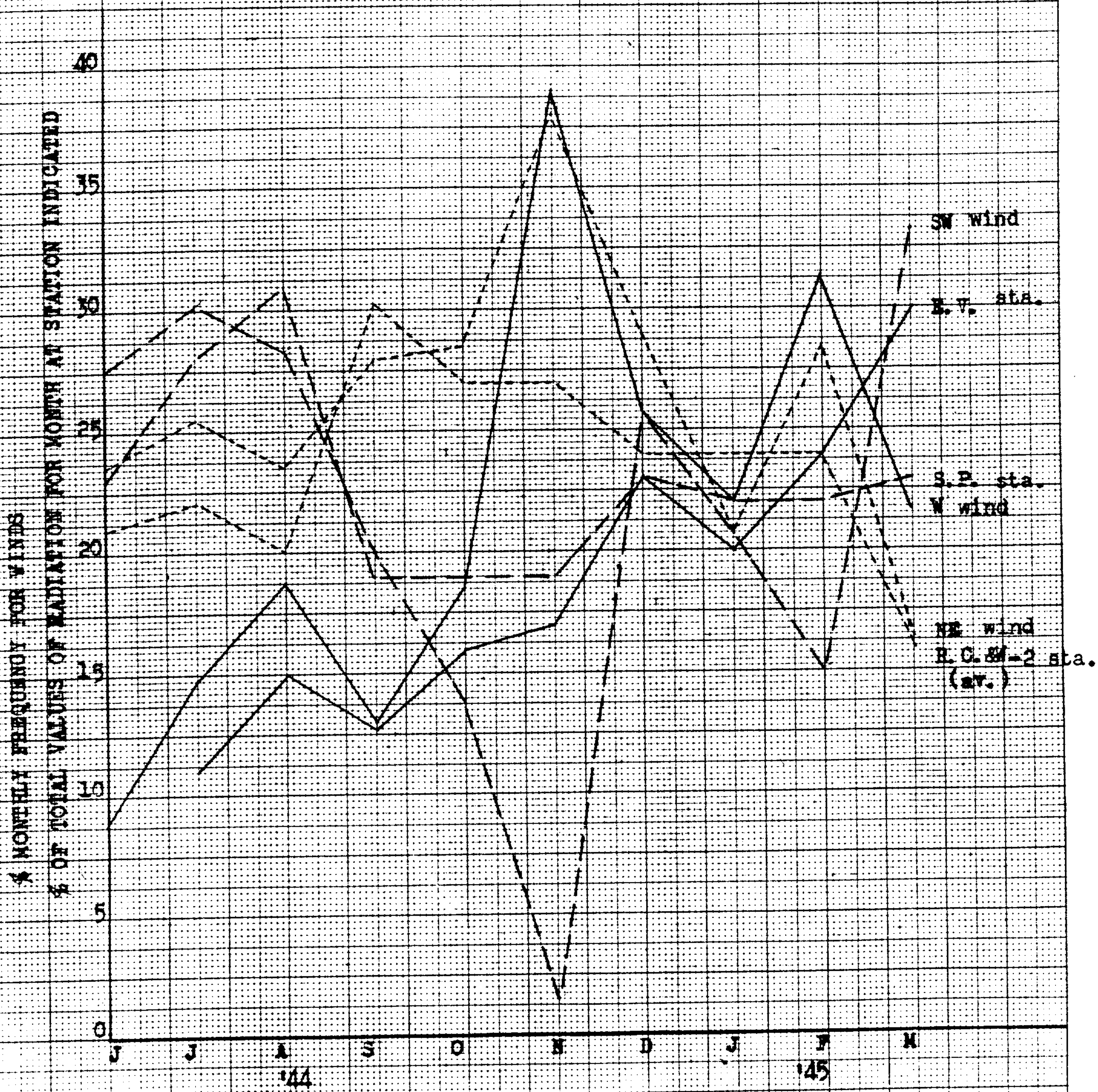
Dr. No. 1800

Fig. #7

CORRELATION CHART SHOWING MONTHLY FREQUENCY OF PREVAILING WINDS AND CORRESPONDING READINGS AT X-22 STATIONS IN THEIR RESPECTIVE PATHS

SITE "X"

NOTE:- Similar lines are used to indicate wind direction and the station in its path.



MAY '45 JSC

[redacted]

As previously mentioned, the Dam station was comparatively shielded from gaseous contaminations by topographical contours. However, since it was about 30 ft. from the shore of White Oak Lake, it served as a good monitoring unit for lake radiations.

At high level, a recording chart at the White Oak Dam would reach about 6'. Whenever the water dropped below this level, mud, previously under water would be exposed as the water level fell. As the insulating effect of the water on this contaminated mud was removed, readings on the X-22 chambers at this station rose. For example, after the water had been at the 6' level for some time, it was dropped to about the 4' level on October 8th. Chamber readings, meanwhile rose from a range of zero to .002 mr/hr above background to a range of .005 to .007 mr/hr above background. When the lake level was dropped to about 2' on November 21, chamber readings rose to an average of ~ .013 mr/hr.

Similar effects, to a lesser degree were noted each time there was some change in the lake level. It was also noted that when the lake level remained constant for any length of time, there was a tendency for the radiation level to fall. This is probably due partly to decay of the active materials in the exposed mud, and partly to erosive effects of rain.

The last station, HP, which is 14,800 ft. from the plant, has an elevation of 1120 ft. It was not affected by the burst slugs. Being almost three miles distant, readings were usually not over .002 mr/hr above background. However, radiation values as high as .02 mr/hr have been observed. Checking the circumstances present with readings of over .01 mr/hr, it was found that these usually occurred when there was a dissolving in progress, and also that the wind was 6 or more mph toward this station.

Results obtained from beta chambers, when present were of not sufficient statistical validity to be more than mentioned. Readings were always somewhat higher than those of gamma chambers, but, since the chamber backgrounds were higher, these values were not as reliable. Moreover, since weather produced large errors because of moisture entering the chambers, even the readings obtained were difficult to evaluate.

The part of the air monitoring program using X-22 chambers was concluded on March 31, 1945. A fairly complete picture of the distribution of gaseous wastes of the plant had been obtained. It had, moreover, been established that atmospheric contamination, even at the plant, did not exceed the order of magnitude of natural backgrounds. Average values for natural background is

[redacted]

on the order of .015 mr/hr, and long-term average station readings, even within 1/2 mile of the plant, were on the order of .005 mr/hr and lower outside this range. Values for short periods as measured with X-22 chambers did not exceed .03 mr/hr, and these values were noted only during dissolvings. Also, on cessation of dissolver operations, the only gaseous contaminant is active Argon which has to be considered purely from the point of view of external radiation effect. Therefore, during the course of normal operation of the plant at "X" the health hazard from atmospheric radiation is altogether negligible.

INTEGRONS

Another of the several methods used for air monitoring was the use of Victoreen integrons, set in specially designed housing units at several points ranging from the plant site to Oak Ridge Village about 10 miles distant. These installations were made in January 1944. The walls of the integron chambers were of about 1.6 mm thickness of bakelite, which would admit most gamma radiations and beta radiations with energies greater than .7 mev. L & N recorders were used to record activity.

Since instrument backgrounds on these integrons were .2 mr/8 hrs or more, the scale was calibrated in mr. These instruments proved not to be sufficiently sensitive for the low radiation levels existing in the area, and nothing of significance was noted. Four of the more distant installations were removed in February 1945.

FILM METERS

To supplement the integron coverage of the area off the plant site, x-ray film meters were used at the Area Gates. Regular film badges were used, placed in a louvered box for reasons of Security. These were read weekly beginning in April 1944. The lowest measurable reading on this type of film is 10 mr. No measurable readings have been noted.

RAINWATER COUNTS

Beta counts were taken on rainwater samples whenever there was a sufficient amount of precipitation. Twenty-eight samples were counted between September 1944 and January 1945. These were evaluated in $\mu\mu$ curie/cc. The values ranged from 0.0 to .33 $\mu\mu$ curie/cc, and averaged .09. Further breakdown showed that -

SECRET

(1) During periods with off-gas the values averaged .151, and .056 without off-gas.

(2) With wind toward the rain-gauge values averaged .123, and .059 otherwise.

(3) With both off-gas and E or NE wind* the average was .174.

*NOTE: The rain gauge is about 300 ft WSW of the 200 stack.

While the above values were small, the data shows good correlation with wind direction, and indicates that washing by rain removes more active contaminant from the dissolver off-gas than from the 105 effluent.

STACK MONITORING UNITS

A monitoring unit for Xenon and Iodine was designed and installed in the 205 stack during the latter part of 1944. It consisted of a continuous sampling line which draws a small percentage of the flow from the off-gas line, passes it through a stripper where Iodine is removed by a caustic solution and then, after drying, through a stainless steel ionization chamber where Xenon activity is measured, then back into the off-gas line. The Iodine, removed in solution by the stripper, passes through another ionization chamber where Iodine activity is measured. The ionization current through each chamber is measured by a Beckman amplifier and recorded by a Micromax recorder.

Charts from this unit show that Xenon activity reaches a peak about one hour after a dissolving begins, and after dropping to about a third in another two hours, tapers off to zero in a total elapsed time of $\sim$12 hours. Iodine activity shows a peak simultaneously with that of Xenon but after a sharp drop shortly afterward does not drop to zero value. This latter effect may be due to condensation of Iodine in the Saran coil of the Iodine chamber.

It was found by graphical integration that the Xenon chamber showed 72 curies for batches 272 and 273. This was twice the calculated value. Similarly, 5.3 curies of Iodine were measured. This is about 7% of the calculated value. It seems, then, that only about 5 - 10% of Iodine generated escapes through the stack (CE-2205).

The 105 stack has a monitoring unit for activated Argon. The gas is sampled through a by-pass. A filter in the system removes solid particles. The values shown by this unit follow a close ratio to pile power level, giving $\sim 10^{-13}$c/cc/kw of pile power.

Since burst slugs are found occasionally in the pile (first one found 8/4/44), a unit was devised to capture the solid particles released by these ruptures. This was more to be used as an indicator for a rupture than as a monitor for activity, since a sharp rise, sometimes as high as twice the normal ionization current, occurs within a very short time after the rupture occurs. This unit was installed about November 1944.

GM TUBE MONITORING UNIT

During the latter part of 1944, work was done on a scaler and recorder circuit using thin-walled glass GM tube to monitor atmospheric radiation. With the development of the ether-neon tube (CP-2594) at the end of January 1945, this unit began giving fairly good results.

The installation was made about 800 ft. NW of the 105 stack. Readings were correlated with wind direction and pile energy indices. For this location, the readings rose approximately 4% of background above background for each mega-watt of pile power independently of wind direction, and about 25% to 40% of background above background when the wind blew toward the unit, i.e. SE wind. Since natural background is about .015 mr/hr maximum values observed here were on the order of .009 mr/hr above background. No valid readings were obtained while the separations plant was in operation, so that the above values were due to pile operations.

This method compares with the X-22 chambers in sensitivity for low radiation levels, and has the further advantages that these can be checked as to time of occurrence and maximum values, and that the apparatus does not require more than a daily check. It does, on the other hand, require a source of electrical power.

XE^{133} DETERMINATION BY AIR SAMPLING

During November and December 1944, determinations were made of the Xenon content of the air down wind from the plant during 205 dissolvings (CE-2209). The procedure consisted of passing 4500 ft^3 of air through an accumulator in the course of an hour, which comprised a "run". Here the air was liquified. The liquid sample was then evaporated through an apparatus which trapped the Xenon by selective adsorption. The sample was then counted by means of a mica-window GM tube.

Eighteen determinations were made, at distances ranging from 150 ft. to 3 miles from the plant, but mainly between .1 and .4 miles. Results obtained ranged from zero to 2.8×10^{-11} curies/ft^3, and averaged 5.06×10^{-12} curies/ft^3. The highest values obtained were at .2 and .4 miles from the plant stack. Tolerance concentration for this gas is 3.5×10^{-7} curies/ft^3.

No I^{131} was detected in these runs. However, the calculated values of Iodine based on Xenon values was below the sensitivity of the apparatus used, so none was expected.